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ABSTRACT

The magnitude of the dichotic right ear advantage was assessed in 48 normal and 48 learning disabled (LD) children (mean age 8.3 years). Ss were matched according to age, sex, and handedness. An analysis of results indicated a significant right ear advantage in both the normal and LD children, but revealed no developmental trend for either group. Differences observed in the performance of LD and normal children may reflect variability in selective attention rather than differences in the degree of cerebral lateralization. Results suggested a need for reconceptualization of the causative factors affecting children with learning disorders and lent support to the notion that cerebral lateralization is not a developmental phenomenon. (Author/SBH)

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ATTENTIONAL BIAS AND THE DEVELOPMENT OF CEREBRAL DOMINANCE IN NORMAL AND LEARNING DISABLED CHILDREN[1]

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- Abstract -

The magnitude of the dichotic right ear advantage was assessed in 48 normal and 48 learning disabled children representing an age range of approximately five years. All subjects were matched according to age, sex, and handedness. An analysis of results indicated a significant right ear advantage in both the normal and learning disabled children, but revealed no developmental trend for either group. Differences observed in the performance of the learning disabled and normal children may reflect variability in selective attention rather than differences in the degree of cerebral lateralization. These results suggest a need for a reconceptualization of the causative factors affecting children with learning disorders and lend support to the notion that cerebral lateralization is not a developmental phenomenon.

The issue as to whether or not cerebral dominance develops for language specialization has received a great deal of attention in the contemporary literature (e.g: Berlin, Hughes, Lowe-Bell, & Berlin, 1973; Hiscock & Kinsbourne, 1978; Porter & Berlin, 1975; Satz, Bakker, Teunissen, Goebel & Van der Vlugt, 1975). On one hand, it has been argued that, at birth, the human infant is truly bilateral in language representation and that, as development progresses, so does the unilateral specialization of language (Berlin, et al., 1973; Porter & Berlin, 1975; Satz, et al., 1973; Lenneberg, 1978). Typically, non-invasive techniqeus such as dichotic listening are

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used where cerebral specialization is inferred through lateral preferences in recognition in the simultaneous presentation of auditory stimuli. While many studies using this technique have provided evidence to support the developmental hypothesis, the clinical literature adds further credibility to this approach (Hecean, 1973). Alternatively, others argue strongly that cerebral lateralization for language does not develop, and that unilateral representation for language is present at birth (Kinsbourne & Hiscock, 1977; Kinsbourne & Hiscock, 1978). Several studies employing dichotically presented words have provided indirect evidence to this position, as a right ear superiority in stimulus recall has been observed in children as young as 2½ years of age (Gilbert & Climan, 1974; Ingram, 1975). The results of other studies using both dichotically presented CV syllables (Hynd & Obrzut, 1977) and words (Schulman-Galambos, 1977) seem to be complimentary to this view, as no developmental trend was reported in subjects ranging from kindergarten age children through college students. Finally, additional support for this approach is provided in studies employing other indicies of funtional asymmetry, such as time sharing (Hiscock & Kinsbourne, 1978) and electo-physiological measurement with infants (Molfese, Freeman, & Palermo, 1975).

Those studies which found no significant developmental trend among their normal subjects have been criticized for using dichotic stimuli (e.g: CV syllables) which may only tap lower levels within CNS functioning (Porter & Berlin, 1975). The similar results of studies employing more advanced stimuli requiring semantic syntactic analysis (e.g: words), however, suggest that this criticism may not be valid (Schulman-Galambos, 1977). Of more concern, perhaps, is the suggestion by Satz, et al. (1973), that the results of studies demonstrating no developmental trend may be contaminated by the insufficient difficulty of the task. When one critically examines studies employing either CV syllables (Hynd & Obrzut, 1977) or words (Schulman-Galambos, 1977), the stimuli seem equally difficult, as total accuracy at any age level representing children in kindergarten through college age subjects never exceeds fifty percent.

The evidence from both dichotic listening studies (Hynd & Obrzut, 1977; Schulman-Galambos, 1977) and other techniques such as time-sharing (Hiscock & Kinsbourne, 1978) seems to add strong support to the position that cerebral dominance is not a developmental phenomenon, and that unilateral speech representation is probably present at birth. If this position is indeed correct, then it calls into question the popular conceptualization that children identified as dyslexic or learning disabled suffer some form of incomplete or delayed cerebral lateralization (Orton, 1937; Critchley, 1970). While some evidence tentatively suggests that this may indeed be the case among both dyslexics (Obrzut, in press) and learning disabled children (Obrzut, Hynd, Obrzut, & Leitget, Note 1), these studies have not employed a control group of normal children with whom to compare resultant indices of cerebral lateralization. Furthermore, other studies which have found no developmental lag in cerebral lateralization employing both dichotic (e.g: Witelson & Rabinovitch, 1971) and visual half-field (e.g: Yeni-Komshian, Isenberg & Goldberg, 1975) paradigms have been criticised by Satz (1976) for various procedural artifacts, thus compromising their potential impact.

Consequently, the purpose of the present investigation was two-fold in nature. First, it was of interest to determine if there was evidence of incomplete lateralization among the clinically identified learning disabled children when compared to a matched normal population. Second, it seemed necessary to determine if there was evidence of a developmental trend in the unilateral representation of language among these children. In other words, were the older children of both the deviant and matched normal population more lateralized for language than those in the younger groups, and, if this was the case, was the difference in the magnitude of the right ear advantage great enough to support the developmental hypothesis?

Method

Subjects

Forty-eight caucasian learning disabled children from a middle class community were selected and voluntarily participated in the study. All subjects were clinically diagnosed as learning disabled by a state certified school psychologist and subsequently placed in a learning disabilities program by a multidisciplinary committee according to state and Federal guidelines.[2] All subjects demonstrated at least average intellectual ability.[3] Of the forty male and eight female subjects, an age range of approximately five years was represented. To facilitate an analysis for a developmental trend in the establishment of cerebral speech lateralization, the subjects were divided into a younger group of twenty-four children (mena age = 8-3; S.D. = 8.19 months) and an equally large group of older children (mean age = 10-6; S.D. = 7.46 months). No significant differences were found in measured intellectual ability between the children participating in the younger and older groups.

Handedness of the subjects was established by observing the subjects' performance on eight activities selected from the Edinburgh Handedness Inventory (Oldfield, 1971). These activities included writing, cutting with

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[2] According to Colorado State guidelines, these children must consistantly exhibit a deficit in processing despite at least normal levels of intelligence (I.Q. > 85). Significant impairment must be identified using individually administered standardized tests (e.g: WISC-R, ITPA, PPVT, and PIAT) in one or more of the following areas: reception, discrimination, association, organization/integration, retention or application. Furthermore, the children in the younger group were required to evidence a developmental delay in at least one of these areas in excess of one year. The children in the older group had to evidence a developmental discrepancy in excess of a year and a half.

[3] WISC-R scores were available on forty-three of the learning disabled children participating in this study. Mean intelligence quotients were: Verbal = 102.50 (S.D. = 12.57); Performance = 104.39 (S.D. = 14.57) and; Full Scale = 103.00 (S.D. = 12.82).

scissors, drawing, using a spoon, using a knife, brushing teeth, throwing a ball, and removing a lid from a box. Using a criteria of five out of eight activities completed with one hand, forty-three subjects were identified as preferring their right hands, while five were determined to be left handed. Employing the procedures suggested by Oldfield (1971), a mean laterality quotient of 76.81 (S.D. = 48.13) was calculated for the learning disabled children. No significant differences were found between the children in the younger and older groups. Prior to their inclusion in the subject population, all children were required to pass an audiometric screening test for frequencies ranging from 400 H_z through 8,000 H_z at a threshhold level of 5 db at each frequency level examined. All of the learning disabled children were required to evidence normal hearing abilities in each ear for inclusion in the subject population. The screening was conducted in a Tracoustics Sound Suite using a Grason-Sandler 1701 audiometer. Once the learning disabled children had been screened and identified as to their handedness, a complimmentary sample of forty-eight normal children were selected who had previously passed a similar audiometric screening test. The subjects were matched according to age, sex, and handedness. Handedness of these subjects was determined using similar procedures as outlined for the learning disabled children. A comparison of the mean laterality quotient for the normal children (mean = 79.25; S.D. = 44.50) with that reported for the learning disabled children revealed no significant differences. Comparable measures of intellectual ability were not available for the matched normal children. As the normal children were selected from the same population as the learning disabled children, the absence of comparable measures of intellectual ability was not believed to be a significant factor in interpreting the results of this study.

Materials and Procedure

The dichotic stimuli consisted of 30 pairs of voiced CV sylables (ba/ka/da/ga/ta/pa/) presented on a synthesized tape prepared at the Kresge Hearing Research Laboratory in Louisiana. The signal-to-noise raito was 40 db, and the channel intensity and resulting earphone volume was adjusted prior to each administration. The interstimulus interval was six seconds, and the presentation of the CV syllables represented all possible non-identical pairings of the dichotic stimuli. As there is some evidence which suggests that task instructions may be a critical variable in lateralization studies (Springer, 1977), care was taken to ensure that the subjects received exactly the same instructions. Consequently, each subject was seen individually and examined in an environment free from external noise and distractions. They were told that they would hear some new words and were presented with a strip of tagboard on which the CV syllables were printed. The examiner then read each CV syllable with the subject repeating after him. Three practice trials were then administered to the subject to confirm their comprehension of what would be required. They were free, however, to report either one or both of the CV syllables presented. The CV syllables were presented to the subjects through a MAICO-24 audiometer using a SONY TC560

tape recorder. The subjects listened to the stimuli through TDH 39 earphones at a hearing threshold of 55 db.

Results

To obtain data for analysis, the number of correctly reported CV syllables were summed for each ear for all subjects. These scores are reported in Table 1 according to developmental levels for both the normal and learning disabled children. All data analysis was computed using the first correctly reported CV syllable per ear summed according to group. Neither handedness or sex had a significant effect on the results, so the scores for these children were grouped together.

A 2 X 2 X 2 (diagnostic group X developmental level X ear) analysis of variance with repeated measures using the correct only scores revealed no significant interactions and two significant main effects. While both the learning disabled and normal children demonstrated a significant right ear effect, F (1,92) = 22.29, $p < .01$, there was a significant difference between these two groups in their performance on the dichotic task, F (1,92) = 36.75, $p < .01$. Despite the significant difference between these two groups, no significant interaction between the ear effect and the performance of the learning disabled and normal children was noted, F (1,92) = .026, $p > .05$. Of special interest, no developmental trend, F (1,92) = 1.83, $p > .05$, was evidenced, indicating that, while there may be differences between the performance of learning disabled and normal children on a dichotic task, both are lateralized for speech representation and do not evidence developmental characteristics.

These results, however, should be viewed tentatively, as there is evidence indicating that analysis of correct only scores may unnecessarily bias results (Harshman & Krashen, 1972; Marshall, Caplan & Holmes, 1975; Birkett, 1977). Consequently, all scores were converted to a percent of error (P.O.E.) index using the formula LE/LE + RE. In this formula, LE represents the number of errors attributed to the left ear while RE would indicate the number of errors attributed to the right ear on the dichotic listening task.

Figure 1 presents the mean percent of error (P.O.E.) contributed by the left ear on the dichotic listening task according to developmental level. The fact that both the normal and learning disabled children are lateralized is demonstrated in the younger children by the P.O.E. index of 53% and 51% respectively. At the older level, the mean P.O.E. index shifts to 56% and 57% respectively for the normal and learning disabled children. As the P.O.E. scores are intended to provide an underlying index of laterality free from the contaminating effects of guessing, it was of interest to reexamine the previously reported results using these corrected scores.

Consequently, an identical three-way ANOVA with repeated measures was computed using the P.O.E. scores, which had been transformed using arcsin transformations. While the significant ear effect, F (1,92) = 16.61, $p < .01$ was still evident, the apparent difference between the performance of the learning disabled and normal children was no longer significant, F (1,92) = 1.21, $p > .05$. Again, no developmental trend, F (1,92) = .59, $p > .05$, or significant interactions were noted. As a result, it seems that the significant differences originally

reported between the learning disabled and matched normal children may be attributable to the effects of guessing rather than to actual differences in the relative degree of cerebral speech lateralization.

Discussion

The results of the present investigation seem significant on three counts: (1) both the learning disabled and normal children evidenced a right ear advantage, thus implying established lateralization for language specialization in these groups; (2) no developmental trend was apparent for either the learning disabled or normal subjects in terms of their demonstrated ability to perceive dichotically presented auditory stimuli; and, (3) a distinct and significant difference was identified in the overall performance of the learning disabled and normal children, despite the fact that both groups achieved similar laterality quotients. While it is this third finding which may be most significant in relation to our understanding of the learning disabled child, the other two points deserve discussion in terms of advancing our knowledge of cerebral lateralization.

Since Orton (1937) originally proposed that children with developmental dyslexia suffered from a failure of the two cerebral hemispheres to differentiate function, countless studies have sought to correlate indices of discrepant lateralization (usually handedness) with learning difficulties. If, as the present results would suggest, difficulties inherent among children experiencing learning problems cannot be attributed to a failure (in the absolute sense) to establish cerebral dominance, then what neuropsychological process does, in fact, contribute to these differences in learning abilities? The finding that both normal and learning disabled children are lateralized for language specialization seems significant in questioning our traditional conceptualization of why children experience learning difficulties. Additionally, it seems that support is given to other studies which have also failed to demonstrate discrepant cerebral lateralization in dyslexic children (e.g: Obrzut, in press; Yeni-Komshian, Isenberg, & Goldberg, 1975).

The finding that no developmental trend was evident in either the normal or learning disabled children further compounds the developmental hypothesis of Lenneberg (1967) and those supportive of this perspective (Berlin, et al., 1973; Porter & Berlin, 1975; Satz, et al., 1975). It could be, as Satz (1976) has argued, that the failure to find a developmental trend is due to a ceiling effect, where both the learning disabled and normal children found the task too easy and, consequently, performed with little variability. However, since neither group was able to correctly identify more than 50% of the CV syllables for either ear, this conclusion seems of little merit. A second possible rationale for a failure to identify a developmental trend would encompass a modification of Lenneberg's (1967) hypothesis as proposed by Krashen (1973). In examining critically the clinical evidence cited by Lenneberg (1967), it seemed more appropriate to conclude that language lateralization was completed at an earlier age than previously suggested. Consequently, it was proposed that unilateral language representation was fully complete at five or six years. Thus, it could be argued that the subjects in this study were too old. While this line of

reasoning has some merit, it would seem that, if the learning disabled children were truly delayed, as is traditionally believed, then the younger group should have evidenced either invomplete lateralization or a much greater discrepancy in performance from their matched normal subjects. This, of course, was not the case, as demonstrated by the failure to find an interaction effect between these variables. Based on the arguments presented here, it would seem that school-age children, both learning disabled and normal, have established cerebral lateralization for language.

The third finding, that learning disabled and normal children differ quantitatively in their dichotic listening performance, seems interesting for several reasons, and may contribute to furthering our understanding of how learning disabled and normal children differ neuropsychologically. An inspection of Table 1 will reveal two items of interest. Despite the fact that there exists a right ear advantage in both groups, the overall ear accuracy of the younger learning disabled children is significantly lower than their normal counterparts. Furthermore, the older learning disabled children achieved their higher P.O.E. index (see Figure 1) not be correctly identifying more CV syllables per ear, but by suppressing the left ear recognition of the dichotic stimuli to a greater extent than the normals. In fact, the number of correct CV syllables identified in the right ear by the older learning disabled children is still lower than that reported for the younger normal children. Despite these differences, it seems that the depressed performance of the learning disabled children was not a factor in their achievement of a P.O.E. index quotient similar to that of their matched normal counterparts. It seems that the analysis of the corrected scores indicates that the learning disabled children are as equally lateralized as the normal subjects, but some factor impedes their overall performance. It may be suggested that the depressing effects of guessing, evidenced in the performance of the learning disabled children, are due to developmental delays in the ability to focus attention.

Kinsbourne (1974) suggested that asymmetries in lateral function may represent biases in attention which are stimuli specific. Furthermore, he suggested that attentional biases to the left hemisphere (such as in speech representation) are accomplished with a reciprocal inhibition of the minor cerebral hemisphere. He also proposed that this phenomenon has a cumulative effect in suppressing the right cerebral hemisphere in similar tasks. The apparent suppression of the stimuli presented to the left ear in the older learning disabled children may reflect the development of selective attention toward the stimuli presented to the right ear. This may be accomplished with consequent inattention to the confounding stimuli received ipsilaterally and across the corpus callosum.

The results reported here seriously question the traditional explanation which attributes learning disabilities to incomplete or delayed cerebral lateralization. They do, however, support an active and possibly developmental model of selective attention. It may be that the variability among children of differing age levels in the ability to selectively attend has contributed to what appears to be developmental trends in the establishment of cerebral dominance. Consequently, the differences observed may be

attributable to deficits in transcallosal functioning rather than to a delay in the shift from bilateral language representation to a unilateral lateralization of function.

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Table 1

Mean Number of Correctly Reported CV Syllables For

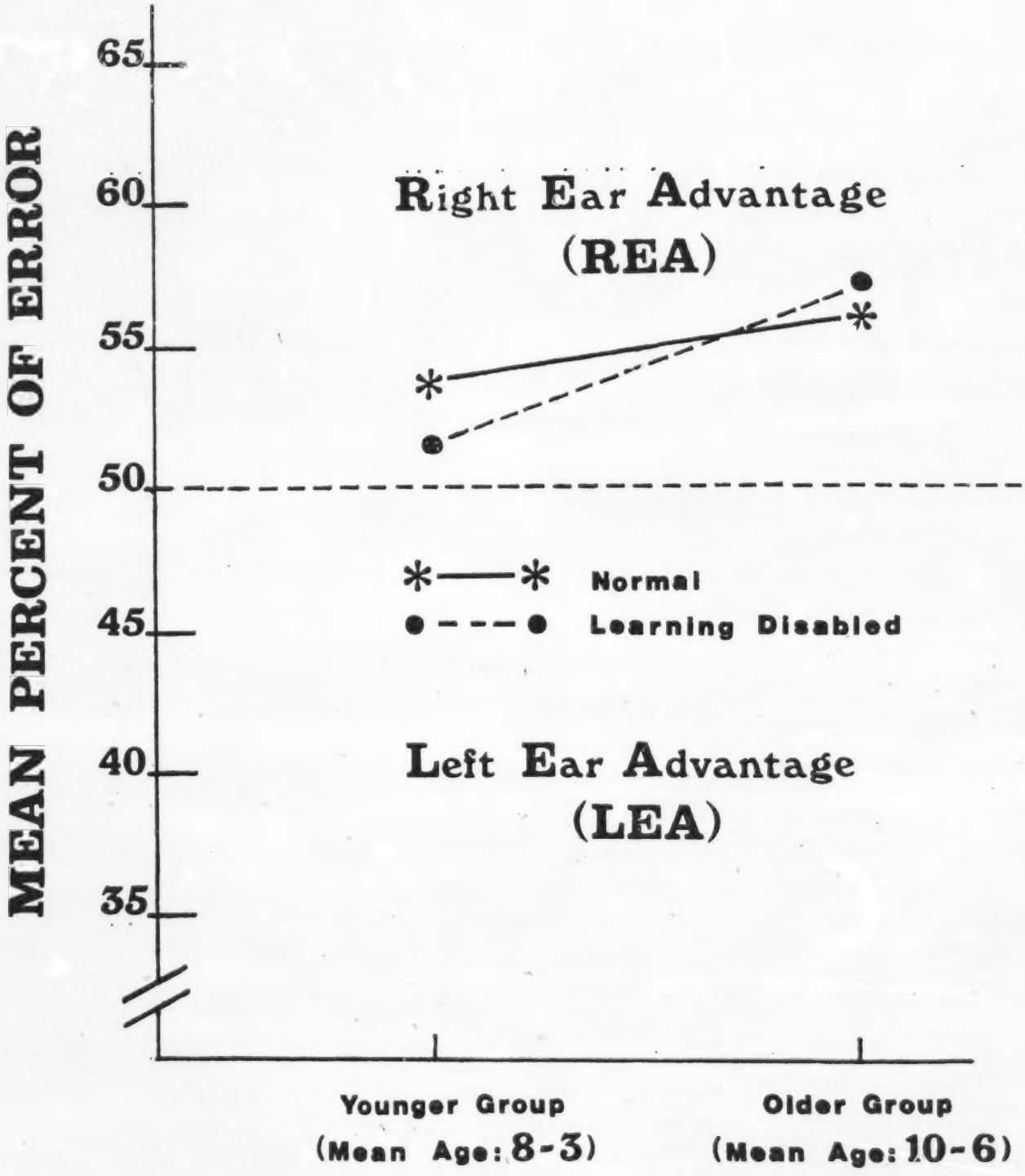
Each Ear by the Normal & Learning Disabled Children

Developmental Level	(Age Range)	N	Left Ear $\bar{X}$	Left Ear S.D.	Right Ear $\bar{X}$	Right Ear S.D.
Learning Disabled	Younger (7-0 to 9-6)	24	10.21	2.67	11.83	3.31
	Older (9-7 to 11-11)	24	8.38	3.56	12.67	5.32
Normal	Younger (7-0 to 9-6)	24	11.67	3.56	14.17	4.59
	Older (9-7 to 11-11)	24	10.58	2.60	14.79	2.61

A total score of 30 was possible for each ear.

Figure Caption

Figure 1. Mean percent of error (P.O.E.) contributed by the left ear on the dichotic listening task according to developmental level.


MEAN PERCENT OF ERROR
65
60
55
50
45
40
35
Right Ear Advantage
(REA)
Left Ear Advantage
(LEA)
Normal
Learning Disabled
Younger Group
(Mean Age: 8-3)
Older Group
(Mean Age: 10-6)
DEVELOPMENTAL LEVELS